

CLAIMS

What is claimed is.

- 1 1. A process of etching a ball-limiting metallurgy (BLM) stack comprising:
 - 2 etching a BLM stack disposed over a metallization, in the presence of a nitrogen-containing heterocyclic compound, an ammonium hydroxide compound, an oxidizer, and
 - 3 a metal halide compound.
- 1 2. The process according to claim 1, wherein etching forms a dissolved portion of
- 2 the metallization, and wherein etching is carried out under conditions that retain the dissolved
- 3 portion of metallization in an oxidized state.
- 1 3. The process according to claim 1, wherein etching forms a dissolved portion of
- 2 the metallization, and wherein etching is carried out under conditions that retain the dissolved
- 3 portion of metallization in an oxidized state, and wherein the conditions include a pH range from
- 4 about 7 to about 12.
- 1 4. The process according to claim 1, wherein the nitrogen-containing heterocyclic
- 2 compound is selected from pyrrole, imidazole, oxazole, thizole, pyrazole, 3-pyrroline,
- 3 pyrrolidine, and n-methyl pyrrolidone.
- 1 5. The process according to claim 1, wherein the ammonium hydroxide compound is
- 2 selected from methyl ammonium hydroxide and tetra methyl ammonium hydroxide.

1 6. The process according to claim 1, wherein the oxidizer is selected from ozone,
2 hydrogen peroxide, and hydrogen peroxide-containing complexes.

1 7. The process according to claim 1, wherein the metal halide salt is selected from
2 alkali metal halide salts and alkaline earth metal halide salts.

1 8. The process according to claim 1, wherein the nitrogen-containing heterocyclic
2 compound includes n-methyl pyrrolidone, wherein the ammonium hydroxide compound includes
3 tetra methyl ammonium hydroxide, wherein the oxidizer includes hydrogen peroxide, and
4 wherein the metal halide compound includes potassium fluoride.

1 9. The process according to claim 1, wherein the metal stack includes a refractory
2 metal first layer, a lead/tin barrier second layer, a refractory metal third layer, and a nickel-
3 vanadium upper layer, and wherein etching further includes:

4 etching the nickel-vanadium upper layer in a first etch; and
5 etching the first-through third layers in the presence of the nitrogen-containing
6 heterocyclic compound, the ammonium hydroxide compound, the oxidizer, and the metal
7 halide compound.

1 10. The process according to claim 1, wherein etching forms a dissolved portion of
2 the metallization, wherein etching is carried out under conditions that retain the dissolved portion
3 of metallization in an oxidized state, wherein the nitrogen-containing heterocyclic compound is
4 n-methyl pyrrolidone (NMP), wherein the ammonium hydroxide compound is tetra methyl

5 ammonium hydroxide (TMAH), wherein the oxidizer is hydrogen peroxide (H_2O_2), wherein the
6 metal halide compound potassium fluoride, and wherein the conditions include
7 NMP:TMAH: H_2O_2 in a volume ratio:

8 that varies the NMP from about 8:5:2 to about 2:5:2;

9 that varies the TMAH from about 5:6:2 to about 5:4:2; and

10 that varies the H_2O_2 from about 5:5:3 to about 5:5:1.

1 11. The process according to claim 1, wherein etching forms a dissolved portion of
2 the metallization, wherein etching is carried out under conditions that retain the dissolved portion
3 of metallization in an oxidized state, and wherein the conditions include the metal halide
4 compound that includes potassium fluoride in a range from about 3 gram/liter to about 5
5 gram/liter.

1 12. The process according to claim 1, wherein etching forms a dissolved portion of
2 the metallization, wherein etching is carried out under conditions that retain the dissolved portion
3 of metallization in an oxidized state, and wherein the conditions include maintaining a
4 temperature in a range from about 25° C to about 50° C.

1 13. The process according to claim 1, wherein etching forms a dissolved portion of
2 the metallization, wherein etching is carried out under conditions that retain the dissolved portion
3 of metallization in an oxidized state, and wherein the conditions include an etch time in a range
4 from about 30 seconds to about 20 minutes.

1 14. The process according to claim 1, wherein etching forms a dissolved portion of
2 the metallization, wherein etching is carried out under conditions that retain the dissolved portion
3 of metallization in an oxidized state, and wherein the conditions include:

4 NMP:TMAH:H₂O₂ in a volume ratio of about 5:5:2;

5 KF in a concentration of about 4 g/liter;

6 an etchant temperature of about 40° C; and

7 an etch time of about 10 minutes.

1 15. A ball-limiting metallurgy (BLM) etching system comprising:
2 a substrate including a metallization pad;
3 a BLM stack including:
4 a metal first layer disposed above and on the metallization pad;
5 a metal second layer disposed above and on the metal first layer;
6 a metal upper layer disposed above the metal second layer;
7 an electrically conductive bump disposed above and on the BLM stack; and
8 an etch recipe that includes:
9 n-methyl pyrrolidone(NMP), tetra methyl ammonium hydroxide (TMAH),
10 hydrogen peroxide (H₂O₂), and potassium fluoride (KF); and
11 etching conditions that resist dissolving the electrically conductive bump.

1 16. The BLM etching system according to claim 15, wherein the etching conditions
2 include NMP:TMAH:H₂O₂ in volume ratio ranges from about 8:5:2 to about 2:5:1, from about
3 5:6:2 to about 5:4:2, and from about 5:5:3 to about 5:5:1.

1 17. The BLM etching system according to claim 15, wherein the etching conditions
2 include KF in a range from about 3 g/liter to about 5 g/liter.

1 18. The BLM etching system according to claim 15, wherein the etching conditions
2 include an etching temperature in a range from about 25° C to about 50° C.

1 19. The BLM etching system according to claim 15, wherein the etching conditions
2 include an etch time in a range from about 30 seconds to about 20 minutes.

1 20. The BLM etching system according to claim 15, wherein the refractory metal
2 upper layer is selected from a refractory metal, metal-doped refractory metal, or a refractory
3 metal alloy selected from Ni, Co, Pd, Pt, NiV, CoV, PdV, PtV, Ti, Zr, Hf, Cr, Mo, W, Sc, Y, La,
4 and Ce in a solid-solution or stoichiometric ratio.

1 21. The BLM etching system according to claim 15, wherein the electrically
2 conductive bump comprises a tin-lead solder composition selected from Sn37Pb, Sn97Pb, and
3 Sn_xPb_y, wherein x+y total 1 and wherein x is in a range from about 0.3 to about 0.99.

1 22. The BLM etching system according to claim 15, further comprising:
2 a metal third layer disposed above and on the metal second layer, wherein the metal third
3 layer is substantially the same metal as the metal first layer.

1 23. A ball-limiting metallurgy (BLM) etching system comprising a solution including
2 a nitrogen-containing heterocyclic compound, an ammonium hydroxide compound, an oxidizer,
3 and a metal halide compound, wherein the solution has a pH greater than or equal to about 7.

1 24. The BLM etching system according to claim 23, wherein the heterocyclic
2 compound includes n-methyl pyrrolidone, wherein the ammonium hydroxide compound includes
3 tetra methyl ammonium hydroxide, wherein the oxidizer includes hydrogen peroxide, and
4 wherein the metal halide compound includes potassium fluoride.

1 25. The BLM etching system according to claim 23,
2 wherein the heterocyclic compound includes about five volume parts n-methyl
3 pyrrolidone;
4 wherein the ammonium hydroxide compound includes about two volume parts
5 25% tetra methyl ammonium hydroxide in water;
6 wherein the oxidizer includes about two volume parts 30% hydrogen peroxide in
7 water; and
8 wherein the metal halide compound includes about 4 gram/liter potassium
9 fluoride in the solution.

1 26. The BLM etching system according to claim 23, wherein the solution is provided
2 in two parts including:
3 a first part containing the heterocyclic compound and the oxidizer; and

4 a second part containing the ammonium hydroxide compound and the metal halide
5 compound.

1 27. The BLM etching system according to claim 23, wherein the solution is provided in three
2 parts including:

3 a first part containing the heterocyclic compound;
4 a second part containing the ammonium hydroxide compound and the metal
5 halide compound; and
6 a third part containing the oxidizer.

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